Coastal Structures Asset Management

Steven A. Hughes, PhD, PE

Coastal and Hydraulics Laboratory
US Army Engineer Research and Development Center
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Email: Steven.A.Hughes@erdc.usace.army.mi

Coastal Structures Asset Management

Key Point

*We are starting with a **clean slate**, and this is an **opportunity** for us to develop a rational and consistent method for managing **O&M expenditures** on critical coastal infrastructure.*

Coastal Structures Asset Management

What's the Problem?

The Problem:

- Tens of Millions $ spent each year repairing structures
- Most structures are over 50 years old (some <100 yrs!)
- Not enough funding to cover the necessary repairs

The Need:

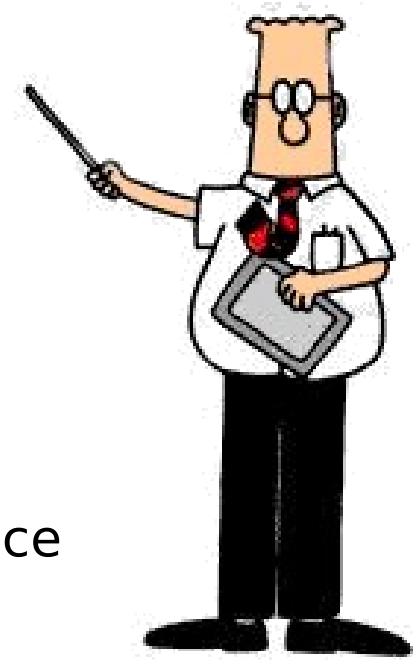
- Rational method for assessing and prioritizing maintenance and repair of structures
- Methodology that is objective, balanced, and fair
- Useful at District, Division, and Headquarters levels

Coastal Structures Asset Management

Technical Approach

Main Tasks

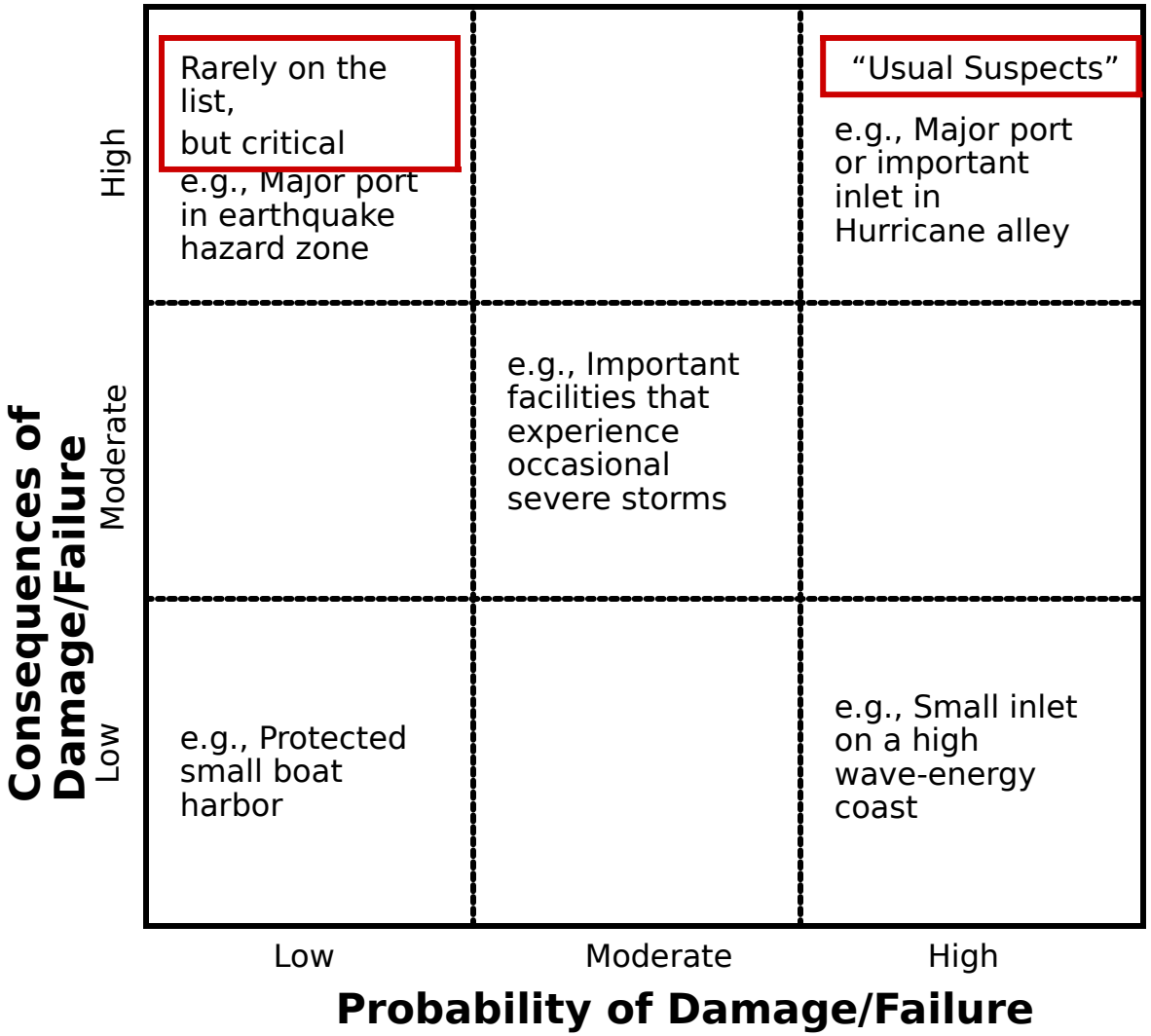
- Establish PDT of District/Division experts
- Identify Corps' critical coastal structures
- Gather data on critical structures
- Develop Asset Management Decision Tool
- Develop improved structure design guidance



And now some details…

US Army Corps of Engineers

Coastal Structures Asset Management



US Army Corps of Engineers

Coastal Structures Asset Management

Develop Asset Management Decision Too

- AMDT includes consideration of…
  - Physical state of structure
  - Risk of additional damage or failure if repair is postponed
  - Decreased project functionality
  - Potential for economic loss (Corps, community, commerce)
  - Impact to Corps' navigation and dredging missions
  - Cost to repair
  - Other?

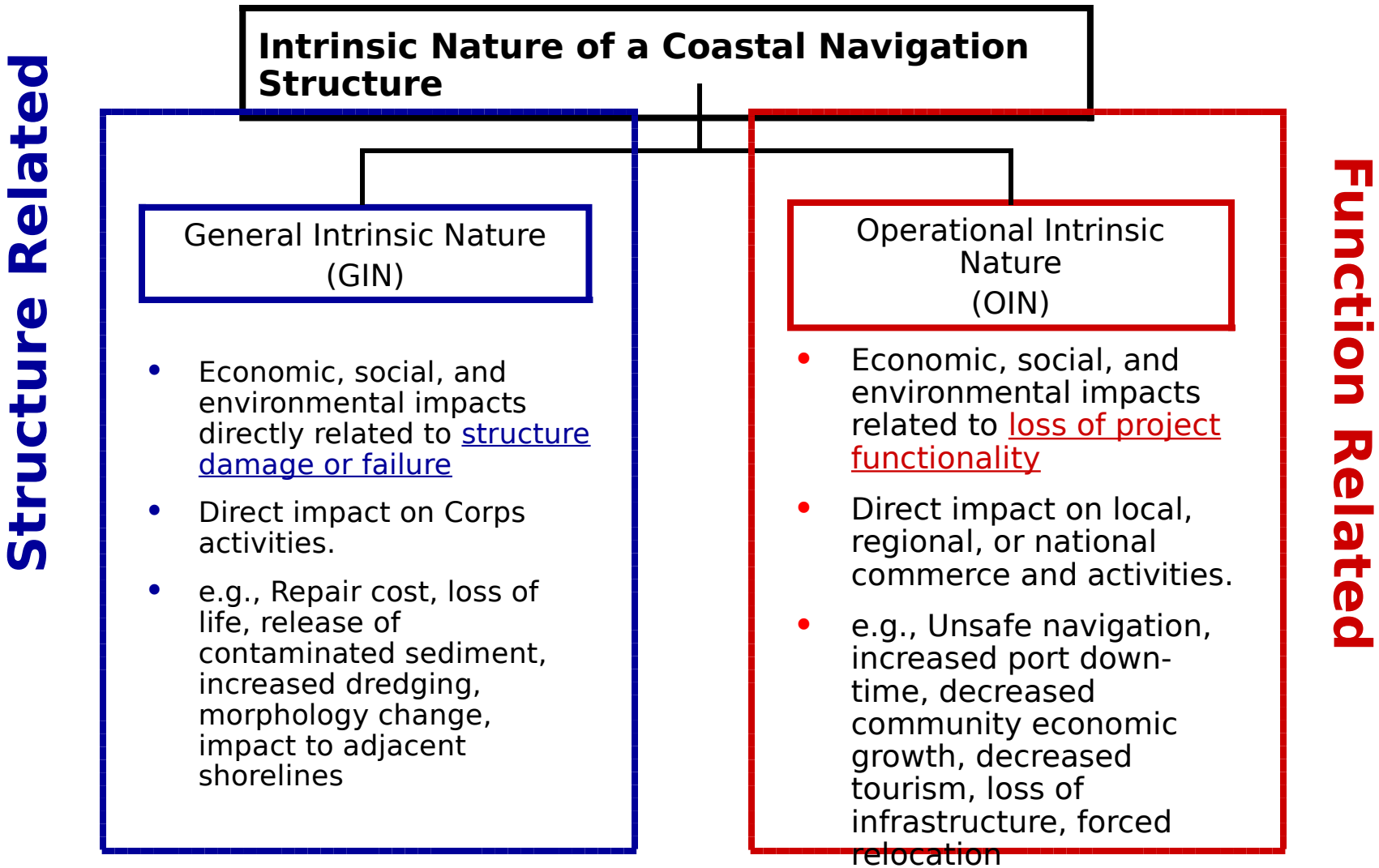
Coastal Structures Asset Management

Critical Components for Evaluating Structures

- Estimate the repair cost and **repercussions** associated with a damaged or failed structure
- Determine the **risk of additional damage** and the associated repercussions if repair is postponed
- Need some indicator of **confidence level** in the estimates
  - **Low** – Based on minimal quantitative information (SWAGs)
  - **Medium** – Some quantitative estimates and some approximate guesses
  - **High** – Based on detailed studies and analyses
- Need proper **weighting** when summing all the diverse elements of assessing risks and consequences arising from a damaged structure

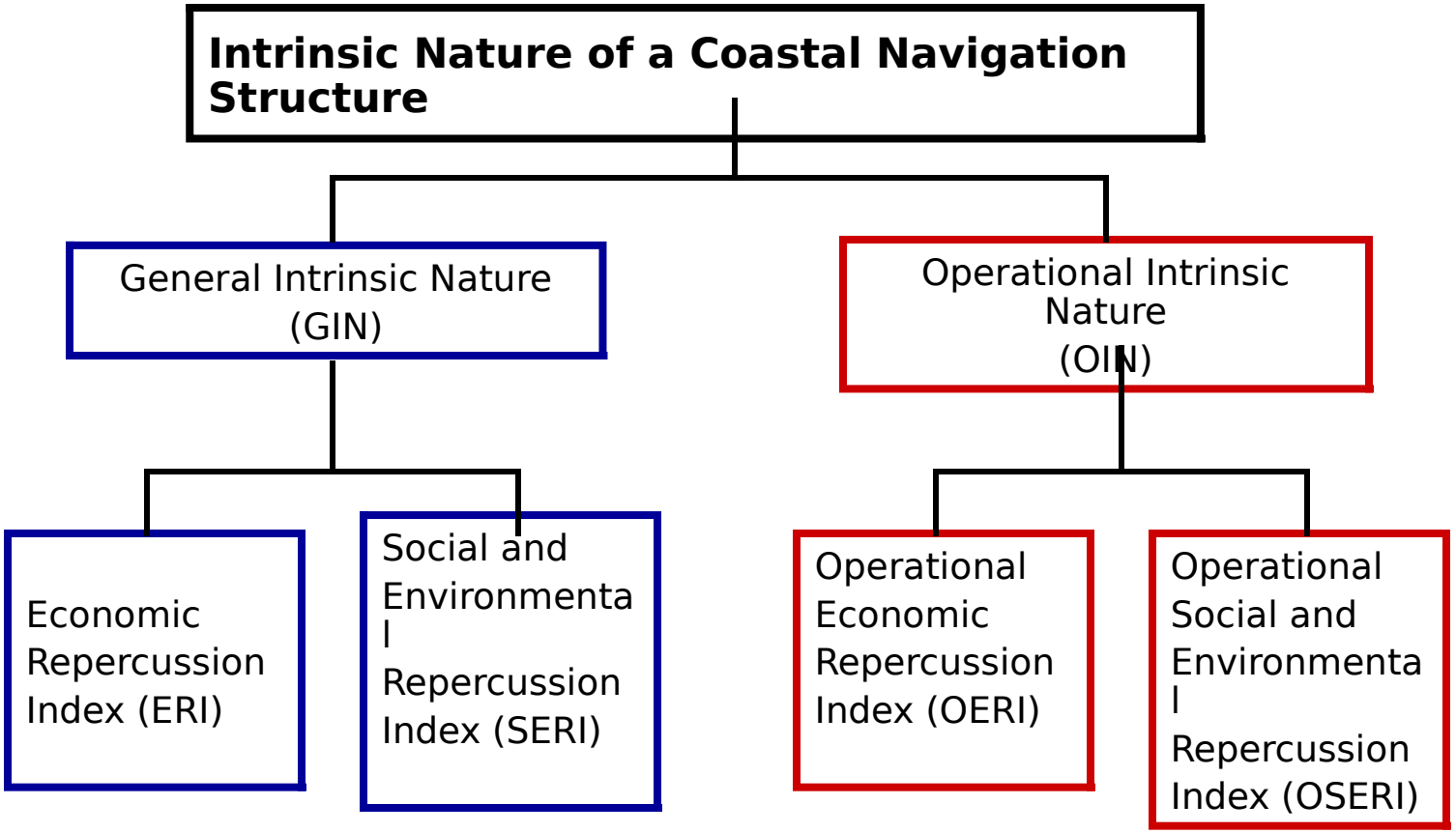
US Army Corps of Engineers

Coastal Structures Asset Management


Intrinsic Nature of a Coastal Navigation Structure
Structure Related
General Intrinsic Nature (GIN)
• Economic, social, and environmental impacts directly related to structure damage or failure
• Direct impact on Corps activities.
• e.g., Repair cost, loss of life, release of contaminated sediment, increased dredging, morphology change, impact to adjacent shorelines
Operational Intrinsic Nature (OIN)
• Economic, social, and environmental impacts related to loss of project functionality
• Direct impact on local, regional, or national commerce and activities.
• e.g., Unsafe navigation, increased port down-time, decreased community economic growth, decreased tourism, loss of infrastructure, forced relocation
Function Related

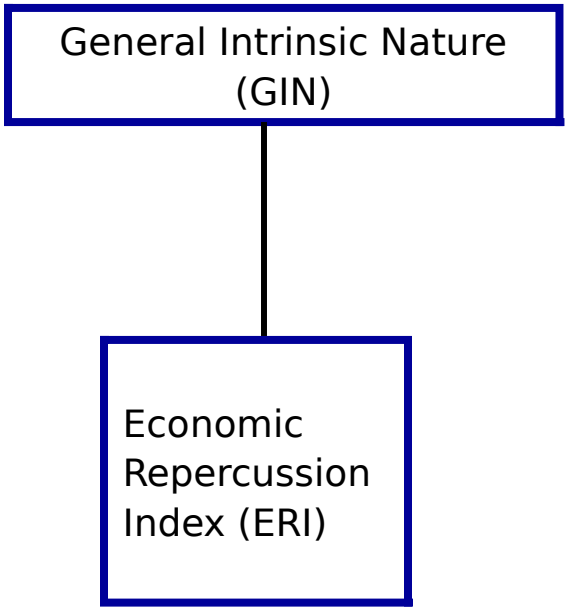
US Army Corps of Engineers

Coastal Structures Asset Management


Intrinsic Nature of a Coastal Navigation Structure
General Intrinsic Nature (GIN)
Operational Intrinsic Nature (OIN)
Economic Repercussion Index (ERI)
Social and Environmental Repercussion Index (SERI)
Operational Economic Repercussion Index (OERI)
Operational Social and Environmental Repercussion Index (OSERI)

US Army Corps of Engineers

Coastal Structures Asset Management

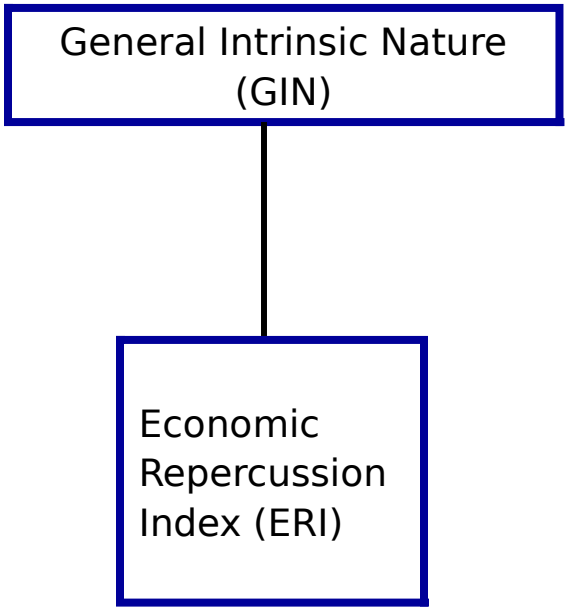


- ERI is a quantitative assessment of foreseeable economic repercussions related to failure of, or damage to, the structure (does not include costs related to loss of functionality)
- The ERI index consists of…
  - **Structure-related costs** (C_{SG}): Total cost incurred by the Corps and cost-share partners to return the structure to functional operation.
  - **Project-related costs** (C_{PG}): Annual project costs incurred by the Corps (and partners) while the structure is in a degraded condition awaiting repair. (Assumes no further structural damage occurs.)
  - **Normalizing factor** (C_{OM}): FY O&M budget?
- ERI is calculated as

$$ERI = \frac{C_{SG} + C_{PG}\,(N \text{ years})}{C_{OM}}$$

US Army Corps of Engineers

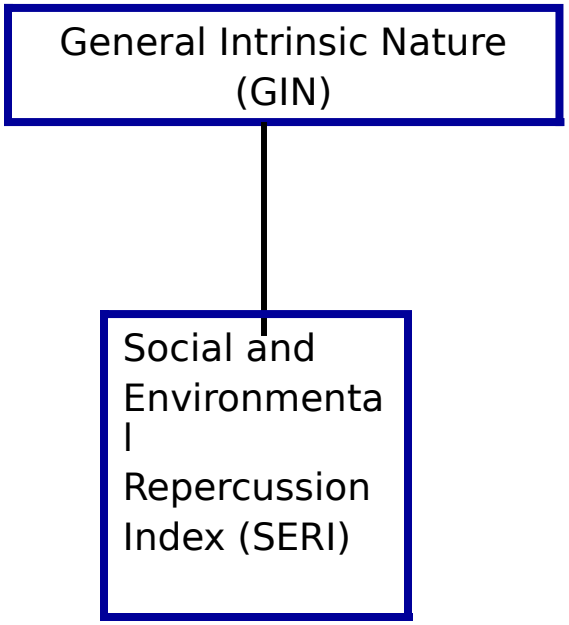
Coastal Structures Asset Management



- **Estimate of C_{SG}** (structure-related costs)
  - Evaluated through detailed studies for actual damage incurred
  - Estimated a priori for different values of structural condition index
  - For total failure – updated initial investment (replacement cost)
- **Estimate of C_{PG}** (project-related costs)
  - Evaluated through detailed studies, site investigations, or modeling studies
  - Annual cost if repair spans multiple years

US Army Corps of Engineers

Coastal Structures Asset Management



- SERI is a qualitative assessment of social and environmental repercussions related to failure of, or damage to, the structure (does not include impacts related to loss of functionality).
- Three factors are included in the SERI index…
  - **Loss of human lives** ($SERI_1$): Evaluates the possibility and scope of loss of human lives due to a damaged or failed structure.
  - **Environment, historical significance, and cultural heritage** ($SERI_2$): Evaluates damage to the environment and/or historical and cultural heritage due to structure damage or failure.
  - **Social disruption** ($SERI_3$): Evaluates social disruption directly attributable to structure damage

US Army Corps of Engineers

Coastal Structures Asset Management

Loss of human lives ($SERI_1$):

- *Remote* – Injury to people is improbable.
- *Low* – Loss of human life is possible (accidental), but not probable. Few people affected.
- *High* – Loss of human life is very probable. Affects a relatively small number of people.
- *Catastrophic* – Loss of human life and injury to people is serious and widespread. Regional medical facilities affected.

Coastal Structures Asset Management

Environment and historical/cultural heritage ($SERI_2$):

- *Remote* – Damage is improbable.
- *Low* – Damage is slight, and reversible within one year. Losses are of little value.
- *Moderate* – Damage is important, but reversible within 5 years, or there is loss of important elements of historical and artistic value.
- *High* – Damage to ecosystem is irreversible, and there is loss of important historic and artistic elements.
- *Very High* – Irreversible ecosystem damage, extinction of protected species, destruction of protected natural resources, or loss of a large number of important elements of historical or artistic value.

US Army Corps of Engineers

Coastal Structures Asset Management

Social disruption ($SERI_3$):

- *Low* – No signs of any significant social disruption associated with damage or failure of the structure.
- *Moderate* – There is minimum social disruption associated with *high* values of the $SERI_1$ and $SERI_2$ indexes.
- *High* – There is minimum social disruption associated with a *catastrophic* value of the $SERI_2$ index.
- *Very High* – There is a maximum degree of social disruption due to a high value of the $SERI_2$ index.

Coastal Structures Asset Management

Approximation of SERI

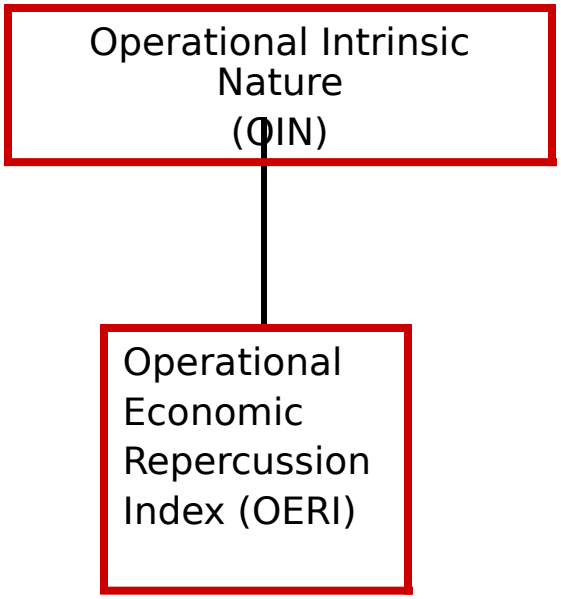
$SERI_1$	Value	$SERI_2$	Value	$SERI_3$	Value
Remote	0	Remote	0	Low	0
Low	3	Low	2	Moderate	5
High	10	Moderate	4	High	10
Catastrophic	20	High	8	Very high	15
		Very high	15		

$$SERI = \frac{SERI_1 + SERI_2 + SERI_3}{50}$$

(SERI index varies between 0 and 1)

US Army Corps of Engineers

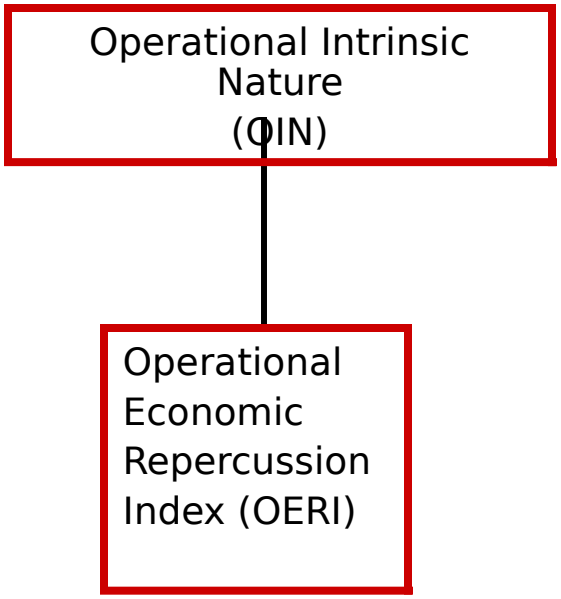
Coastal Structures Asset Management



- OERI is a quantitative assessment of foreseeable economic repercussions related to loss of project functionality.
- Applicable costs consists of…
  - **Loss of income or productivity**: (C_{EO}) Annual losses directly related to decreased project functionality. Does not directly impact Corps of Engineers budget, but does impact local, regional, or national economies
  - **Loss of potential future development**: (C_{FO}) Annual costs related to delay of planned development that was expected to boost the economy at local, regional, or national level.

US Army Corps of Engineers

Coastal Structures Asset Management



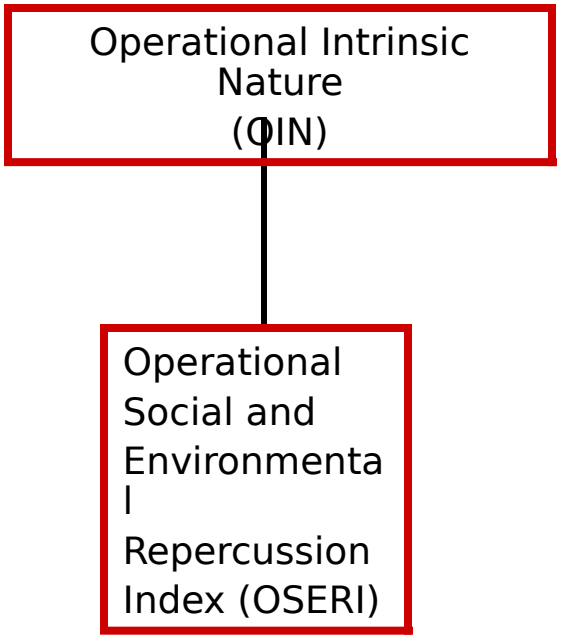
- OERI is calculated as a fraction of structure repair costs as…

$$OERI = \frac{(C_{EO} + C_{FO})\ (N \text{ years})}{C_{OM}}$$

- **Estimate of C_{EO} :**
  - Evaluated through detailed studies
  - Includes direct economic loss and any additional costs incurred to compensate (e.g., fishing harbor)
- **Estimate of C_{FO} :**
  - Based on actual development in planning stages
  - Difficult to quantify

US Army Corps of Engineers

Coastal Structures Asset Management



- OSERI is a qualitative assessment of social and environmental repercussions related to loss of project functionality.
- Three factors are included in the OSERI index are the same as used in the SERI index…
  - **Loss of human lives** ($OSERI_1$): Evaluates the possibility and scope of loss of human lives due to loss of project functionally.
  - **Environment, historical significance, and cultural heritage** ($OSERI_2$): Evaluates damage to the environment and/or historical and cultural heritage due to loss of project functionality.
  - **Social disruption** ($OSERI_3$): Evaluates social disruption directly attributable to loss of functionality
- OSERI is estimated using the same method as SERI

Coastal Structures Asset Management

Total Damage Repercussions Index

$$DRI = \underbrace{W_E\,(ERI) + W_{OE}\,(OERI)}_{\text{tangible costs}} + \underbrace{W_S\,(SERI) + W_{OS}\,(OSERI)}_{\text{intangible repercussions}}$$

where W_E, W_{OE}, W_S, and W_{OS} are weighting factors

- Assumes no additional structure damage occurs between the present and the time in the future when repairs are made.
- Major obstacle is assigning the weighting factors
- Needs to have an associated indicator of DRI quality

Coastal Structures Asset Management

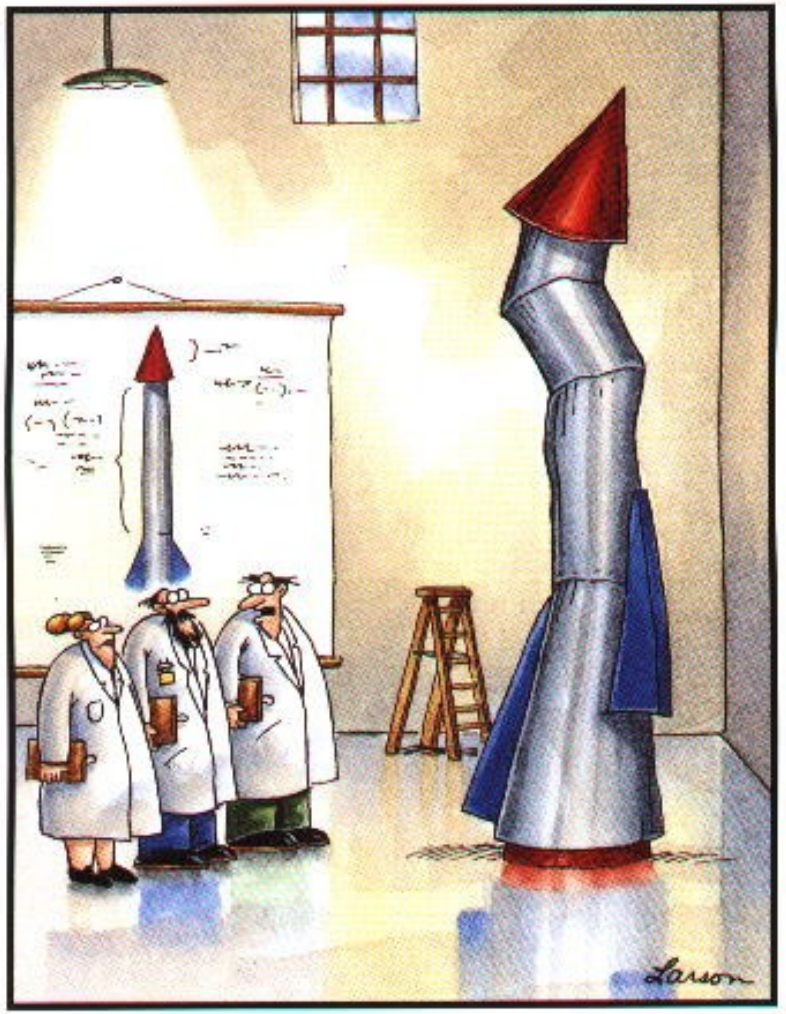
Future Damage Repercussions Inde

- Probability distribution of DRI values associated with the risk of additional structure damage.
- Gauges the consequences of **NOT** undertaking repairs at this time. Essentially an indicator of repair ***urgency***.
- Uses traditional risk analysis to determine probability (and extent) of additional damage, then assigns an estimate of the DRI index for that damage level.
- Also carries along an indicator of DRI estimate quality

US Army Corps of Engineers

Coastal Structures Asset Management

Questions?



"It's time we face reality, my friends. ...
We're not exactly rocket scientists."